COMMERCIAL EVALUATION OF MULTIPLE-SEQUENTIAL INTERVENTIONS FOR DECONTAMINATION OF BEEF CARCASSES

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Summary

Sequential interventions were evaluated to determine their efficacy in reducing beef carcass contamination during commercial application in each of 8 packing plants. Their efficacy was evaluated by sponge swab sampling and microbiological analysis. Mean (log_{10} CFU/100 cm^2) total plate counts (TPC), total coliform counts (TCC) and *Escherichia coli* counts (ECC) on the exterior hide were in the ranges of 8.2 to 12.5, 6.0 to 7.9 and 5.5 to 7.5, respectively, while corresponding contamination levels on carcass surfaces following hide removal but prior to the application of any decontamination intervention were in the ranges of 6.1 to 9.1, 3.0 to 6.0 and 2.6 to 5.3, respectively. After decontamination and a 24 to 36 hr chilling period, mean TPC, TCC and ECC on carcass surfaces were 2.3 to 5.3, 0.9 to 1.3 and 0.9, respectively. Salmonella isolation rates decreased from 14.7% prior to any intervention, to 1.9% after carcass decontamination. Results support the concept of using multiple intervention decontamination processes as a means of improving the microbiological quality of beef carcasses.

Key Words: commercial evaluation, decontamination system, beef carcasses

Introduction

In 1992-1993, Escherichia coli O157:H7 was involved in causing hemorrhagic colitis and hemolytic uremic syndrome in several hundred people in the western United States. The primary vehicle of transmission was undercooked ground beef that had been consumed at fast-food restaurants. Following that outbreak, the Food Safety and Inspection Service of the United States Department of Agriculture issued a policy, known as "Zero Tolerance", requiring the trimming of all fecal, ingesta and udder contents from beef carcasses before carcass washing in order to improve the cleanliness and microbiological status of beef. In July 1996, FSIS published new regulations for meat and poultry inspection employing the concept of Hazard Analysis and Critical Control Point (HACCP) systems (Federal Register, 1996). These new regulations included microbiological performance criteria to evaluate slaughter facilities as they operate under HACCP in order to reduce the incidence of pathogenic microorganisms on meat and reduce the occurrence of foodborne illness associated with the consumption of those products (Federal Register, 1996). These changes prompted the red meat industry to seek ways to meet these requirements to produce beef of improved microbiological quality. In this study, we evaluated the efficacy of multiple decontamination interventions for improving the microbiological quality of beef carcasses in commercial operations.

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Materials and Methods

Sampling for microbiological analysis was conducted during routine operation in 8 different Monfort/ConAgra Red Meat beef slaughtering operations, of which 5 were steer/heifer plants and the remaining 3 were bull/cow plants. The following commercial interventions were involved in some or all of the decontamination systems evaluated: steam vacuuming, in a concentrated area following hide removal; pre-evisceration carcass washing (85°F to 100°F water at 28 to 48 psi), immediately following steam vacuuming; organic acid application (lactic or acetic acid solution at 110 to 140°F and 46 to 47psi), after pre-evisceration washing at a concentration of 1.6% to 2.6%; thermal pasteurization (160°F to 170°F water at 10 psi to 33 psi), following "zero tolerance" inspection; final washing (60°F to 90°F water at 70 psi to 130 psi), following thermal pasteurization; and a final organic acid rinsing application (lactic or acetic acid solution at 110 to 140°F and 46 to 47psi), after final washing and immediately prior to chilling at a concentration of 1.6% to 2.6%. In the first 4 steer/heifer operations, the decontamination system evaluated consisted of: steam vacuuming, pre-evisceration washing, acetic acid application, thermal pasteurization, final washing and a final acetic acid application followed by a 36 h chilling period. In steer/heifer operation number 5, the decontamination system was identical to that which was used in plants 1 through 4 with the exception of acetic acid application which was not used at either site and a decreased chilling period to 24 h. In all 3 of the bull/heifer operations (plants 6 through 8), the decontamination system evaluated consisted of steam vacuuming, thermal pasteurization, final washing and a lactic acid application followed by a 24 h chilling period. Sponge sampling occurred at 4 different in-plant locations during the slaughter/dressing process. In-plant locations included: (1) hide-on (site 1), which was post-exsanguination but prior to hide opening, (2) hide-off (site 2), followed the dehiding process but was prior to any intervention application, (3) after final wash (site 3), immediately following the final wash cabinet and any organic acid application but prior to chilling, and (4) after chilling (site 4), 24 to 36 h after the initial chilling period but prior to entering the sales cooler or fabrication. At each in-plant location, 40 carcass sides were sampled. Hide-on sponge samples were taken at site 1 to determine the external microbiological loads on the incoming cattle since this is a primary source of beef carcass contamination. Carcasses sampled at site 1 were visually tracked until arriving at site 2, at which point one of the sides was sampled to determine the microbiological load of the carcasses prior to any intervention application. Contamination at this point is attributable to physical contact, both human and mechanical, involved in the dehiding process and any aerosols, or airborne bacteria, which might have been present. Following sampling at site 2, unsampled sides were tagged to make identification easier for site 3 sampling. The remaining unsampled sides were then sponge sampled at site 3 to determine the microbiological loads on the carcasses after the last intervention in the system had been applied. Sampled carcasses were tracked through the entire slaughter/dressing process and tag transfer was documented in order to prevent any resampling of carcass sides at site 4, and to ensure that site 4 samples were taken from adjacent, same lot carcasses as those sampled at sites 1,2 and 3, respectively. Sampling by sponging followed the procedures set forth by the United States Department of Agriculture/Food Safety and Inspection Service (USDA/FSIS) (Federal Register, 1996). Sponging at each of the 3 anatomical carcass

sites (100 cm^2 each) consisted of 10 passes vertically (up-and-down being considered as 1 pass) and 10 passes horizontally (side-to-side being considered as 1 pass) with a pressure equivalent to that which would be used to remove dried blood from the carcass. The three carcass sites included: (a) flank, at a point where the medial border of the cutaneous flank muscle comes to within 3 inches of the midline, (b) brisket, at a point on the midline that is level with the elbow and (c) rump, at a point where a line from the posterior aspect of the aitch bone to the achilles tendon intersects the cut surface of the round. Samples were packed with icepacks and a cardboard pad, to prevent direct contact, into shipping coolers for overnight delivery to Warren Analytical Laboratory (Greeley, CO).

Following arrival at the laboratory, the sponges and associated buffer were palpated in a stomacher (Seward Model 400, Tekmar Company, Cincinnati, OH) for 1 minute and appropriate serial dilutions were made based on past test results and background sample results. Samples collected from sites 1 and 3 were analyzed for total plate counts (TPC), total coliform counts (TCC), *Escherichia coli* counts (ECC) and presumptive Salmonella isolation, while samples collected from sites 2 and 4 were analyzed for TPC, TCC and ECC. Analyses were conducted according to approved procedures.

Microbiological quantitative data for TPC, TCC and ECC was transformed to log_{10} CFU/100 cm^2 for statistical analyses, while presumptive *Salmonella* data was reported as a frequency (100*(# of positive samples/# of total samples tested)). Analyses of variance and mean separation tests for comparisons of mean counts (log_{10} CFU/100 cm^2) at the different in-plant sampling locations were completed using the General Linear Models procedure of SAS® (SAS®, 1995). Chi-square statistic was used to determine differences in presumptive-positive *Salmonella* levels. All statistically significant differences were reported at the $P<0.05$ level.

Results and Discussion

Minimum detection levels for TPC, TCC and ECC were 2.2, 0.9 and 0.9 log CFU/100 cm^2, respectively, based on the maximum sensitivity at a dilution factor of 0. Initial hide-on mean TPC, TCC and ECC, across all plants, ranged from 8.2 to 12.5, 6.0 to 7.9 and 5.5 to 7.5 log CFU/100 cm^2, respectively, while corresponding counts after the hide was removed ranged from 6.1 to 9.1, 3.0 to 6.0 and 2.6 to 5.3 log CFU/100 cm^2, respectively (Tables 1-3). The microbiological loads carried by the carcasses at the hide-off site indicated the amount of microbiological contamination that had taken place during the dehiding process. It was this contamination that the multiple-sequential interventions targeted for decontamination. Following the multiple-sequential interventions that were being utilized in each of the plants, the TPC, TCC and ECC prior to chilling were in the ranges of 3.8 to 7.1, 1.5 to 3.7 and 1.0 to 3.0 log CFU/100 cm^2, respectively, with corresponding counts after the chilling period in the ranges of 2.3 to 5.3, 0.9 to 1.3 and 0.9 log CFU/100 cm^2, respectively (Tables 1-3). In all 8 slaughtering facilities, regardless of slaughter type or intervention system used, there were significant TPC reductions achieved between the hide-off, after final wash and after chilling sampling sites (Table 1). There were significant TCC reductions achieved between the hide-off and after final wash sampling sites in 7 of the 8 facilities with 6 of those demonstrating a significant reduction following chilling (Table 2). In all 8 slaughtering

facilities, there was a significant reduction in ECC between the hide-off and after final wash sampling sites with 5 of those showing a significant reduction following chilling (Table 3). In individual plant analyses, it is possible that significant differences between the after final wash and after chilling sites were masked as the TCC and ECC approached the minimum detection level of the test.

Salmonella isolation results showed a significant decrease in the frequency of the pathogen between the hide-on and after final wash sampling sites. Among the 320 samples analyzed, at each of the 2 sites between all slaughtering facilities, the percent occurrence dropped from 14.7% at site 2 to 1.9% at site 3.

Table 1
Mean total plate counts (TPC)

			Carcass Surface		
PLANT	N[1]	External Hide Surface Mean[2] (SD)[3]	Before Evisceration Mean[2] (SD)[3]	After Final Wash Mean[2] (SD)[3]	After Chilling Mean[2] (SD)[3]
1	160	8.9^{ay} (.59)	6.1^{bz} (1.11)	3.9^{cz} (1.12)	2.8^{dy} (.49)
2	160	12.5^{ax} (2.3)	8.1^{bwx} (1.22)	7.1^{cv} (1.60)	5.3^{dw} (1.15)
3	160	9.2^{ay} (.22)	7.9^{bx} (.92)	4.7^{cy} (1.07)	3.4^{dxy} (.78)
4	160	8.9^{ay} (.93)	8.1^{bwx} (.94)	5.2^{cx} (.95)	2.9^{dy} (.81)
5	159	8.2^{az} (.38)	6.3^{bz} (.80)	3.8^{cz} (.65)	2.3^{dz} (.35)
6	160	9.2^{ay} (.51)	8.3^{bw} (.80)	5.8^{cw} (.98)	2.9^{dy} (.80)
7	160	9.0^{ay} (.36)	6.8^{by} (.96)	5.3^{cx} (1.08)	3.0^{dy} (.71)
8	160	9.2^{ay} (.52)	9.1^{av} (1.42)	7.0^{bv} (1.01)	3.5^{cx} (.70)
AVG	1279	9.4^{a} (1.53)	7.6^{b} (1.45)	5.4^{c} (1.59)	3.3^{d} (1.12)

[1] The number of samples analyzed from each plant (40 at each sampling site); differences from N = 160 are due to technical errors during laboratory analysis.

[2] Mean log colony forming units/cm^2 with a different superscript letter are different ($P<0.05$), for ^{abcd} values in any given row and ^{vwxyz} values in any given column. The detection level is 2.2 log colony forming units/cm^2.

[3] Standard deviation of the mean.

Table 2
Mean total coliform counts (TCC)

			Carcass Surface		
PLANT	N[1]	External Hide Surface Mean[2] (SD)[3]	Before Evisceration Mean[2] (SD)[3]	After Final Wash Mean[2] (SD)[3]	After Chilling Mean[2] (SD)[3]
1	160	7.0^{ay} (.42)	3.0^{bz} (1.07)	1.5^{cz} (.60)	0.9^{dz} (.01)
2	160	7.9^{aw} (.37)	4.4^{bx} (.65)	3.2^{cv} (.54)	1.0^{dz} (.41)
3	160	7.5^{ax} (.26)	4.9^{bw} (.75)	1.7^{cyz} (1.03)	0.9^{dz} (.16)
4	160	7.7^{awx} (.58)	5.7^{bv} (.98)	1.8^{cxyz} (.77)	0.9^{dz} (.01)
5	159	6.0^{az} (.60)	4.0^{by} (.93)	1.8^{cxy} (.79)	0.9^{cz} (.06)
6	160	6.2^{az} (.68)	4.1^{bxy} (.81)	3.7^{bu} (1.10)	0.9^{cz} (.15)
7	160	7.0^{ay} (.36)	4.4^{bx} (.97)	2.0^{cx} (1.05)	0.9^{dz} (.23)
8	160	7.4^{ax} (.69)	6.0^{bv} (.99)	2.7^{cw} (1.36)	1.3^{cy} (.64)
AVG	1279	7.1^{a} (.83)	4.6^{b} (1.27)	2.3^{c} (1.20)	1.0^{d} (.31)

[1] The number of samples analyzed from each plant (40 at each sampling site); differences from N = 160 are due to technical errors during laboratory analysis.

[2] Mean log colony forming units/cm^2 with a different superscript letter are different ($P<0.05$), for ^{abcd} values in any given row and ^{uvwxyz} values in any given column. The detection level is 0.9 log colony forming units/cm^2.

[3] Standard deviation of the mean.

Table 3
Mean *Escherichia* coli counts (ECC)

			Carcass Surface		
PLANT	N[1]	External Hide Surface Mean[2] (SD)[3]	Before Evisceration Mean[2] (SD)[3]	After Final Wash Mean[2] (SD)[3]	After Chilling Mean[2] (SD)[3]
1	160	6.8^{ax} (.47)	2.6^{bz} (1.05)	1.4^{cy} (.55)	0.9^{d} (.01)
2	160	7.3^{aw} (.35)	4.0^{bx} (.78)	3.0^{cx} (.29)	0.9^{d} (.32)
3	160	6.7^{ax} (.44)	4.2^{bwx} (.78)	1.4^{cy} (.89)	0.9^{d} (.00)
4	160	7.5^{aw} (.57)	5.3^{bv} (1.04)	1.5^{cy} (.77)	0.9^{d} (.01)
5	160	5.9^{ay} (.50)	3.7^{by} (.98)	1.0^{cz} (.38)	0.9^{c} (.00)
6	160	5.5^{az} (.75)	3.5^{by} (.81)	1.2^{cyz} (.64)	0.9^{c} (.10)
7	160	6.9^{ax} (.34)	4.3^{bw} (.96)	1.3^{cy} (.78)	0.9^{d} (.00)
8	160	7.2^{aw} (.71)	5.3^{bv} (1.13)	1.2^{cyz} (1.01)	0.9^{c} (.05)
AVG	1280	6.7^{a} (.84)	4.1^{b} (1.25)	1.5^{c} (.91)	0.9^{d} (.12)

[1] The number of samples analyzed from each plant (40 at each sampling site); differences from N = 160 are due to technical errors during laboratory analysis.

[2] Mean log colony forming units/cm^2 with a different superscript letter are different ($P<0.05$), for ^{abcd} values in any given row and ^{vwxyz} values in any given column. The detection level is 0.9 log colony forming units/cm^2.

[3] Standard deviation of the mean.

Implications

When averaging across all of the plants, TPC, TCC and ECC were all significantly reduced between each of the 4 in-plant sampling locations. These results, combined with the decrease in Salmonella isolation, support the concept of using multiple intervention decontamination processes as a means of improving the microbiological quality of beef carcasses and meeting microbiological performance criteria, or standards, in the USDA/FSIS regulations involving HACCP protocols.

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